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All-Cause Readmission and Repeat Revascularization After Percutaneous Coronary Intervention in a Cohort of Medicare Patients

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Objectives The purpose of this study was to report on the all-cause readmission and repeat revascularization rates after percutaneous coronary intervention (PCI).

Background Although PCIs are frequently performed, 30-day rates of readmission and repeat revascularization after PCI are not known.

Methods Retrospective analysis of a cohort of Medicare fee-for-service admissions associated with a PCI in 2005. Primary outcomes were 30-day all-cause readmission rates and 30-day readmission rates associated with a revascularization procedure.

Results A total of 315,241 PCI procedures performed at 1,108 hospitals were included in the analysis. The all-cause 30-day readmission rate was 14.6%, and the all-cause 30-day mortality rate was 1.0%. All-cause 30-day mortality among readmitted patients was higher than patients who were not readmitted (3.6% vs. 0.6%; $p < 0.001$). The 30-day readmission rate of acute myocardial infarction (AMI) patients was significantly higher than that of non-AMI patients (AMI 17.5%, non-AMI 13.6%, $p < 0.001$). Among all patients readmitted within 30 days after the index PCI, 27.5% had an associated revascularization procedure (PCI 25.8%, coronary artery bypass grafting 1.7%). The median readmission rates varied across hospitals, from 8.9% in the lowest decile to 22.0% in the highest decile.

Conclusions A substantial proportion of PCI patients are readmitted within 30 days of discharge, and readmission rates vary widely across hospitals. Readmissions within 30 days of an index PCI procedure were associated with a significantly higher 30-day mortality rate, and more than one-quarter of such readmissions resulted in a repeat revascularization procedure. These findings warrant further attention to determine whether these readmissions are preventable. (J Am Coll Cardiol 2009;54:903–7) © 2009 by the American College of Cardiology Foundation

Prior research has shown that readmission rates for many conditions and procedures are influenced by the quality of inpatient and outpatient care, hospital system characteristics, and local practice patterns (1). Although percutaneous coronary interventions (PCIs) are among the most frequently performed procedures in the U.S. (2), contemporary patterns of readmission after PCI have not been described. At present, there is limited information regarding not only the overall readmission rate after PCI, but also the specific

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Abbreviations and Acronyms

AMI = acute myocardial infarction

FFS = fee for service

ICD-9-CM = International Classification of Diseases-9th Revision-Clinical Modification

PCI = percutaneous coronary intervention

causes for readmission, the rates of repeat revascularization, and the extent of variation in readmission rates across PCI hospitals. Accordingly, we analyzed Medicare fee-for-service (FFS) administrative data to describe readmission rates after PCI. Although limited to older patients, Medicare FFS has the largest share of PCI patients in the U.S. among all payors, and the data are organized in a manner that allows linking patient data across hospitalizations.

Methods

Study cohort. We analyzed 2005 claims data from the Medicare Inpatient Standard Analytical Files and used the Medicare Enrollment Database to determine both Medicare FFS enrollment status and vital status. An index admission was defined as a hospitalization for a Medicare FFS patient 65 years and older during which a PCI was performed. We used the following procedure codes to define PCI: International Classification of Diseases-9th Revision-Clinical Modification (ICD-9-CM) procedure codes 00.66, 36.01, 36.02, 36.05, 36.06, and 36.07. Because our focus was readmission, we excluded hospitalizations during which the patient died or was transferred out to another acute care facility. Patients who had been transferred in from another acute care facility and subsequently underwent PCI were included in the study cohort. In order to obtain reliable estimates of hospital readmission rates, we further restricted our analysis to admissions at hospitals that performed at least 50 PCIs on Medicare FFS patients during 2005. For patients who underwent more than 1 PCI within a 30-day period, the first admission was classified as an index hospitalization, and subsequent admissions with a PCI were classified as readmissions.

Outcomes. The principal outcome was all-cause 30-day readmission, defined as an admission to an acute care hospital for any reason within 30 days of discharge after an index hospitalization. In addition, we considered readmissions within 30 days of discharge associated with either a PCI or coronary artery bypass grafting (ICD-9-CM procedure codes 36.10 to 36.16), and 30-day mortality after discharge.

Analysis. We determined unadjusted all-cause 30-day readmission rates and compared characteristics of PCI patients who had at least 1 readmission with patients who were not readmitted. Readmissions within 30 days of discharge were categorized by the associated principal ICD-9-CM discharge diagnosis code. In addition, we identified the proportion of 30-day readmissions that were associated with a revascularization procedure, again categorizing by associated principal discharge diagnosis code. We determined unadjusted 30-day all-cause readmission rates for individual hospitals and examined between-hospital variation in 30-day all-cause readmission rates and 30-day rates of repeat revascularization. Analyses were repeated after stratifying index admissions by presence or absence of a myocardial infarction (ICD-9-CM principal diagnosis code is 410, excluding those when the fifth digit of the code is 2). Finally, we examined differences in readmission rates by specific hospital characteristics, including PCI volume, teaching status, profit status, and specialty. Because PCI performed in the first 30 days of 2005 could represent a readmission after PCI in December 2004, we repeated the analysis limiting it to patients who underwent PCI admitted between February and December 2005. Analyses were performed using SAS version 9.1 (SAS Institute, Cary, North Carolina) and were approved by the Yale Human Investigation Committee.

Results

In 2005, a total of 400,147 FFS Medicare patient admissions at 1,499 hospitals had an associated PCI. We excluded admissions in which the patient was <65 years of age (n = 55,340), died during the index hospitalization (n = 6,302), was transferred to another acute care facility (n = 4,991), or had a previous PCI admission within 30 days (n = 11,350). We further excluded index admissions at hospitals that performed fewer than 50 PCIs during 2005 (n = 6,923), leaving 315,241 PCI procedures performed on 298,395 patients at 1,108 hospitals.

For the overall study cohort, the 30-day all-cause readmission rate was 14.6%, and the 30-day all-cause mortality rate was 1.0%. Compared with patients who were not readmitted, patients who were readmitted were slightly older (age 75.5 years vs. 74.4 years) and more likely to be female (46.0% vs. 41.0%) and to have diabetes (36.4% vs. 31.7%), heart failure (20.3% vs. 11.3%), renal failure (8.7% vs. 4.0%), or prior ischemic heart disease (21.4% vs. 17.4%). Patients who were readmitted were more likely to die within 30 days of discharge compared with patients who were not readmitted (3.3% vs. 0.6%). The 30-day readmission rate of patients who had an acute myocardial infarction (AMI) during their index admission was significantly higher than that of non-AMI patients (AMI 17.5%, non-AMI 13.6%, $p < 0.001$). Results were comparable when we restricted the cohort to PCIs performed between February and December 2005.

In analyses stratified by hospital characteristics, there were statistically significant but clinically modest differences in overall readmission rates across categories. Specifically, readmission rates were comparable across volume of PCI (≤200: 14.7%, 201 to 400: 14.3%, >400: 14.8%; $p = 0.002$), profit status (not-for-profit: 14.7%, for profit: 14.3%, governmental: 14.2%; $p = 0.048$), teaching status (Council of Teaching Hospitals: 15.0%, non–Council of Teaching Hospitals: 14.1%, nonteaching: 14.6%; $p < 0.001$), and specialty

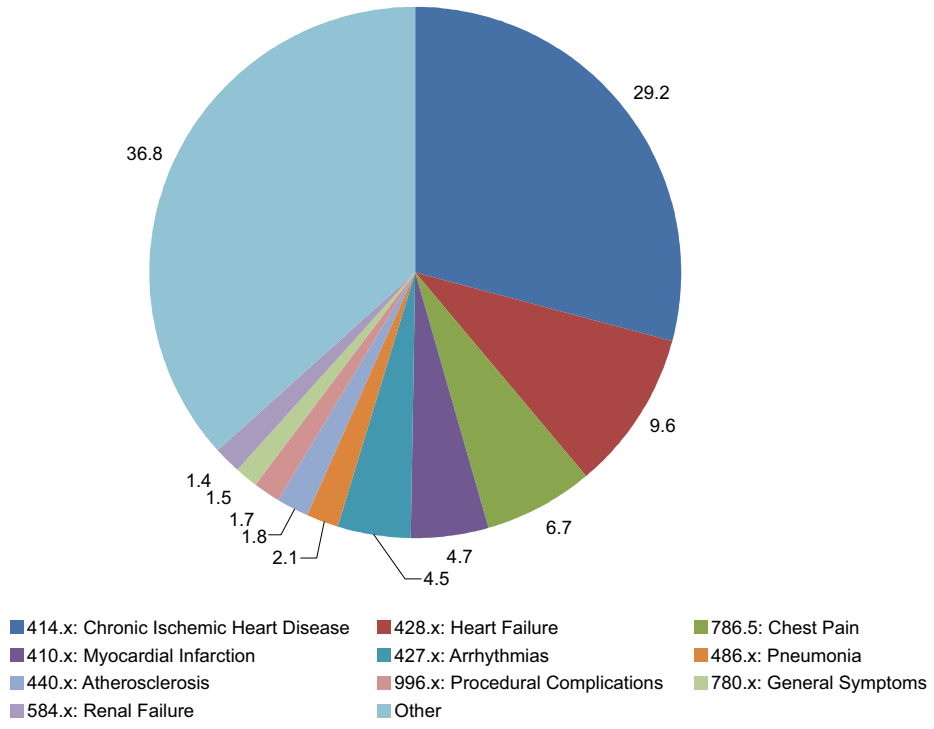

Figure 1 Frequency of Principal ICD-9-CM Codes Among Patients Readmitted After Percutaneous Coronary Intervention

ICD-9-CM = International Classification of Diseases-9th Revision-Clinical Modification.

(specialty heart hospital: 13.1%, nonspecialty hospital 14.6%; $p < 0.001$).

The 10 most frequent principal diagnostic codes associated with readmissions are presented in Figure 1. The majority of rehospitalizations were associated with a cardiovascular principal discharge diagnostic code, and the most common principal discharge diagnostic code was chronic ischemic heart disease (ICD-9-CM 414.xx). Fewer than one-fifth of readmissions were associated with acute cardiovascular conditions codes such as AMI, unstable angina, arrhythmia, or heart failure. Patients whose index PCI was performed during an AMI admission were more likely to have an acute cardiovascular condition as the principal diagnosis for readmission (Table 1). Among all readmissions, 27.5% had an associated revascularization procedure (PCI 25.8%, coronary artery bypass grafting 1.7%). The majority (84%) of admissions with revascularization procedures were associated with principal discharge diagnosis code 414.xx (chronic ischemic cardiac disease).

Table 1 Principal Discharge Diagnosis Codes Associated With Readmissions After PCI in the Overall Cohort as Well as in Subsets of Patients Without AMI, With AMI, and With Repeat Revascularization

Principal Discharge Diagnosis Code	Description	Total (%) (n = 45,964)	No AMI in Index (%) (n = 31,938)	AMI in Index (%) (n = 14,026)	Revascularization During Readmission (%) (n = 12,565)
414.x	Chronic ischemic heart disease	29.2	31.1	25.0	84.4
428.x	Heart failure	9.6	7.5	14.5	1.0
786.5	Chest pain	6.7	7.2	5.5	0.1
410.x	Myocardial infarction	4.7	3.5	7.3	9.5
427.x	Arrhythmias	4.5	4.6	4.2	0.3
486.x	Pneumonia	2.1	1.9	2.5	<0.1
440.x	Atherosclerosis	1.8	2.2	0.6	0.1
996.x	Procedural complications	1.7	1.8	1.6	2.6
780.x	General symptoms	1.5	1.6	1.5	<0.1
584.x	Renal failure	1.4	1.2	1.8	<0.1
Other	Other	36.8	37.4	35.4	2.0

AMI = acute myocardial infarction; PCI = percutaneous coronary intervention.

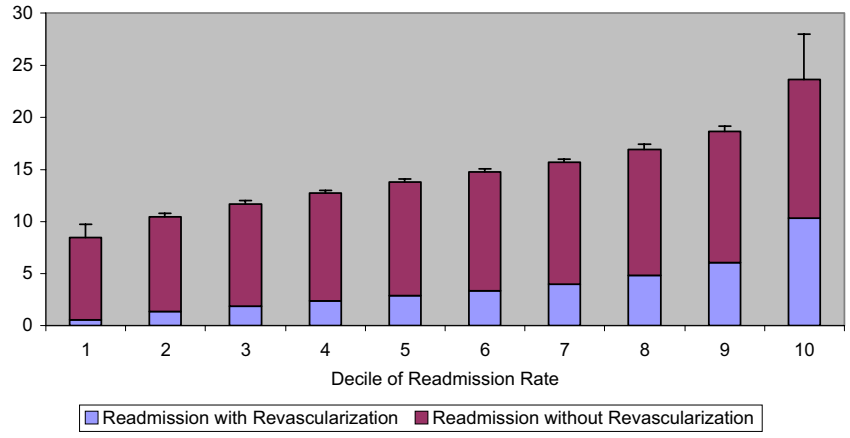

Figure 2 **Mean Unadjusted Hospital Readmission Rates by Hospital Decile of Readmission**

Proportion of readmissions with **(purple)** and without **(pink)** an associated revascularization procedure.

The median readmission rates varied across hospitals, from 8.9% at the lowest decile to 22.0% at the highest decile (Fig. 2). Differences in readmission rates with a revascularization procedure accounted for a portion of the variation across hospital deciles, from 1.8% in the lowest decile to 8.2% in the highest decile. However, there was also substantial variation in readmissions without revascularization, from 6.6% in the lowest decile to 15.4% in the highest.

Discussion

Among Medicare FFS patients who undergo PCI, 1 in 7 are readmitted within 30 days of hospital discharge. Approximately one-quarter of these readmissions were associated with additional revascularization procedures, predominantly repeat PCI procedures. Patients who were readmitted were at significantly higher risk of mortality. Furthermore, readmission rates varied substantially across hospitals, with a >2-fold differential in median readmission rates across hospital deciles. These findings highlight the need to understand the correlates and causes of readmission of discharge after PCI, and to develop strategies aimed at avoiding preventable readmissions.

The topic of all-cause readmissions after PCI has not received much attention from researchers, payors, or regulatory agencies. To our knowledge, no large cohort studies have reported 30-day all-cause readmission rates. Reported 1-year readmission rates are high, ranging from 29% to 52% depending on patient status, use of coronary stents, and health care system studied (3,4). Our finding that 15% of PCI patients were readmitted within 30 days of discharge thereby expands the literature, and the shorter window of evaluation makes it more likely that these readmissions were attributable to the acuity of the presenting cardiac condition, as well as the care delivered both during the index hospitalization and the transition period immediately after discharge.

In addition, we identified significant variation in unadjusted hospital readmission rates in this older cohort. The absence of detailed information regarding comorbidities, cardiac status, and coronary anatomy prevents drawing conclusions regarding differences in readmission rates across hospitals. However, these findings do raise the possibility that some hospitals have already implemented systems of care that prevent potentially avoidable complications, such as bleeding, abrupt vessel closure, and subacute stent thrombosis. Researchers have already demonstrated that quality-improvement efforts improve patient outcomes (5), and studies of patients with heart failure have identified strategies that can effectively reduce readmission rates in these populations (6).

The reasons for readmission after PCI fall into several broad categories: procedural complications, such as vessel closure, bleeding, or contrast nephropathy; planned processes of care, such as a staged procedure for patients with multivessel disease; or consequences of underlying cardiac disease and comorbid conditions. In general, studies of PCI have focused on cause-specific readmissions, such as myocardial infarction or target vessel revascularization (7,8). This approach may be appropriate for randomized controlled trials of PCI efficacy, but may not be aligned with a patient's general preference to avoid rehospitalizations. In this context, all-cause readmission rates may also be a meaningful outcome. The importance of this distinction is highlighted by our finding that only 29% of readmissions were associated with either an AMI or repeat revascularization procedure. Focusing exclusively on cause-specific readmissions would overlook the majority of readmissions after PCI and obscure a potentially important indicator of the care delivered to PCI patients.

Assessing the influence of staged revascularization procedures using administrative claims data is challenging. Many PCI patients have multivessel disease, and there are

several approaches to this population, including performing multivessel PCI, staging repeat procedures within the index hospitalization, pursuing medical therapy, or, relevant to the present analysis, readmitting patients for an elective, staged PCI. All of these approaches may be reasonable, depending on the coronary anatomy and clinical context of individual patients (9). In the present analysis, one-quarter of readmissions were associated with a repeat revascularization procedure. However, we could not determine what proportion of repeat revascularization procedures was truly elective. Nevertheless, even if readmissions with repeat revascularization were removed from consideration, the resulting 10.6% 30-day readmission rate and significant variation across hospitals suggests that focusing on readmission after PCI may represent an opportunity to improve the efficiency of care.

Several aspects of this analysis merit further consideration. First, Medicare patients as a group are vulnerable to readmission, and prior research has demonstrated comparable readmission rates among patients undergoing other invasive procedures. Accordingly, our findings could be reflective of a broader problem, rather than one specific to cardiovascular medicine. Nevertheless, the observation that so many patients are readmitted after PCI should focus attention on this issue, both with regard to PCI-specific interventions, as well as more general strategies aimed at a broader population. Second, as discussed previously, administrative claims data lack detailed information necessary to draw inferences about the underlying causes of differences in readmission rates across hospitals. Accordingly, these findings should be considered hypothesis generating, rather than definitive. Third, the analysis considered only FFS Medicare patients, and readmission rates may be lower among PCI patients with other types of insurance. Nevertheless, Medicare patients are both the largest population of PCI patients in the U.S. and the sickest group, given their advanced age and high rates of comorbid conditions.

Conclusions

In summary, we found that a substantial proportion of PCI patients are readmitted within 30 days of discharge and that readmission rates vary widely across hospitals. The issue of readmission after PCI has been neglected, but warrants further attention to determine whether a proportion of these readmissions are preventable, and if so, what strategies are most effective at reducing readmission rates.

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Key Words: angioplasty ■ quality of care ■ readmission.